TF
1
C2
1920
no. 3
Engineering

ENDRY, President
W. A. BOOTH, Secretary
E. E. LLOYD, Treasurer

OFFICIAL PROCEEDINGS
Meeting of March, 1920

ume XIX.
No. - - - 3

25c. per copy

VICTORIA UNIVERSITY LIBRARY

INCORPORATED OCTOBER 1913

Canadian Railway Club

MONTREAL

PARVA SUB INGENTI

CONTENTS

REPORT OF MARCH MEETING

AND

PAPER AND DISCUSSION

ON

"A FEW GENERAL OBSERVATIONS ON LOCOMOTIVE VALVE MOTION."

TUCO PRODUCTS CORPORATION.
Passenger Car Specialties—National Standard Roofing—Tuco Flexolithe Composition Flooring—Trap Doors "National" and "Universal"—Window Screens "Imperial" and "Universal"—Insulation "Tucork" and "Resisto."

LIBERTY MANUFACTURING COMPANY.
Arch Tube Cleaners.

STANDARD PAINT & VARNISH CO.
Paints and Varnishes.

NATHAN MANUFACTURING COMPANY.
Lubricators, Injectors, Top Checks, Side Checks and everything in brass for the locomotive.

BROWN & CO., INCORPORATED.
Stay Bolt and Engine Bolt Iron.

RIVET CUTTING GUN COMPANY.
Rivet Cutting Gun—Slag Gun.

ADAMS & WESTLAKE COMPANY.

HARRY VISSERING & COMPANY.
Locomotive Bell Ringers and Sanders.

SELLING AGENTS: The Consolidated Equipment Company Limited
263 ST. JAMES ST., MONTREAL.

THE BOSS LOCK NUT

The Boss Nut applied.

Is now safeguarding the rolling stock of all the principal railroads and insuring them against wrecks and derailments. When specifying lock nuts write it right and specify Boss Lock Nuts. It is the last turn of the nut that locks.

Boss Lock Nut Company of Canada - Limited

Head Office . 263 St. James Street, MONTREAL
AND
413 McIntyre Building - - - WINNIPEG

AUG 19 1913

The Robert Mitchell Co., Ltd.

Established 1851 — **Montreal, P.Q.** — Incorporated 1896

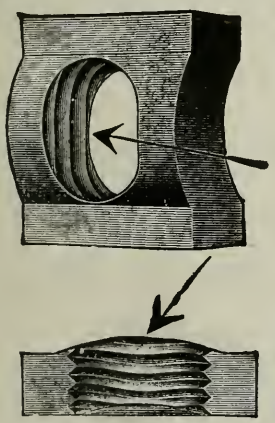
Manufacturers of

Railway Car Fittings

Gas and Electric Light Fixtures

and Brass Goods for Engineers,

Plumbers, and Steamfitters



This cut shows an exaggerated curve in thread pitch.

'Grip Nuts Lock'

Simplicity, efficiency and economy are three reasons why GRIP NUTS lead the field

Easy to apply, absolute in locking, simple to remove

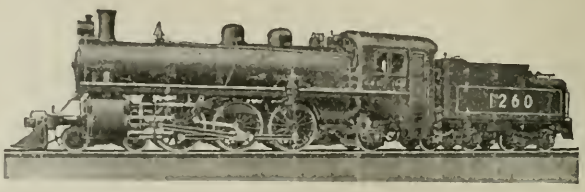
For Particulars, Write

Canada Grip Nut Company, Ltd.

MONTREAL, Que.

PACIFIC TYPE PASSENGER LOCOMOTIVE

CANADIAN PACIFIC RAILWAY



Total weight of engine, 223,000 pounds
Weight on drivers, 142,000 pounds
Diameter of drivers, 70 inches
Boiler pressure, 200 pounds
Cylinders, 22½ x 28 inches
Maximum tractive power, 34,500 pounds

MONTREAL LOCOMOTIVE WORKS, LTD.
DOMINION EXPRESS BUILDINGS, MONTREAL, CANADA

"REDSTONE"

HIGH PRESSURE SHEET PACKING

(Made in Canada)

A PACKING THAT WILL HOLD

From actual tests, we believe that this packing is the most durable and satisfactory of any on the market. Try a sample lot and see for yourself.

Manufactured solely by

GUTTA PERCHA & RUBBER, Limited

TORONTO, MONTREAL, FORT WILLIAM, WINNIPEG, REGINA, SASKATOON, CALGARY, EDMONTON, VANCOUVER.

Canadian Consolidated Rubber Co.

LIMITED

Executive Offices: Montreal, Que.

"SERVICE" Branches and Warehouses in the Largest Centres throughout Canada,

Largest Manufacturers of Rubber Goods In The British Empire

Air Brake Hose (Regular) and Special "Non-freezing."
Air Signal Hose.
Steam Heating Hose.
Vacuum Hose.
Hot Water Hose (white)
Cold Water Hose.
Air Hose—For Drills & Pneumatic Tools.
Hose Bags--Corrugated
Heavy Suction Hose.
Wire-lined Gas Hose.
Fire Hose and Supplies.
And Hose for Every Special Use.

Red Sheet Packing.
"Canadian" Spiral Packing.
Pure Gum Sheet.
Valves—For Hot and Cold Water (all densities for any pressure).
Pebbled (Dot) Rubber.
Moulded Car Mats.
Hammer Bumpers.
Air Brake Gaskets.
Special Moulded Goods, for every Mechanical Use.
Tubing—All sizes.
Rubber Strips.

Rubber Boots and Shoes: "Jacques Cartier," "Merchants," "Dominion," "Daisy," and "Maple Leaf" Brands.

"FLEET FOOT" SPORTING AND OUTING SHOES

DOMINION RAYNSTERS. "MADE-IN-CANADA" RAINCOATS

"DOMINION" Nobby Tread Auto Tires, Truck Tires, Carriage Tires, Motorcycle and Bicycle Tires.

Original "Diamond" Design Inlaid Rubber for Standard Traps and Platforms and Interiors of Cars. Estimates and Samples cheerfully furnished.

RUBBER GOODS FOR ALL PURPOSES

Armstrong Whitworth of Canada

LIMITED

Works: Longueuil, Que.

MANUFACTURERS IN CANADA OF

Locomotive and Car Wheel Tires

HIGH SPEED AND CARBON TOOL STEEL

Montreal, Toronto, Hamilton, Winnipeg

CAST STEEL

TRUCK BOLSTERS
PENN COUPLERS
DRAFT ARMS
TRUCK SIDE FRAME
DRAFT GEARS
LOCOMOTIVE and CAR CASTINGS

FORGED and ROLLED STEEL

CAR AXLES
LOCOMOTIVE AXLES
FORGING BILLETS
PLATES and SHEETS

Dominion Foundries and Steel

LIMITED

HAMILTON - - ONTARIO

THE

PENN FREIGHT COUPLER

Overhead or Underneath Release without
:: :: :: change in details of coupler :: :: ::

Five square inches bearing surface
:: :: :: between lock and knuckle :: :: ::

All the Up-to-Date Features:
"Lock-to-the-Lock," "Lock-Set," and "Knuckle-Opener"

Licensee for Canada

Dominion Steel Foundry Co., Ltd.

HAMILTON, ONT.

Take No Chances, Specify

B.&W. WATER TUBE Boilers

BABCOCK & WILCOX, LIMITED
ST. HENRY, MONTREAL

VAPOR CAR HEATING CO. (Inc.)

RAILWAY EXCHANGE—CHICAGO

Successor to

Chicago Car Heating Co. and
Standard Heat & Ventilation Co. (Inc.)

NEW YORK, BOSTON MASS

MONTREAL, Que.
61 DALHOUSIE STREET

WASHINGTON, D.C., ATLANTA, Ga.

F. A. PURDY, *Sales Representative.* **S. P. HARRIMAN,** *Canadian Agent.*

JOHNS-MANVILLE RAILROAD SUPPLIES

Locomotive Lagging, Locomotive Spiral Pipe Covering, Locomotive Packings, including Air Pump, Throttle, Valve Stem, Cab Cock, Gaskets, etc.; Rofings, Mastic Flooring, Transite and Ebony Asbestos Wood, Transite Smoke Jacks, Refrigerator and Steel Passenger Car Insulation, Pipe Coverings for all classes of service; High Pressure, Low Pressure and Sheet Packings; High Temperature Cements, Steam Traps, Insulating Cements, Electrical Supplies, Automatic Slack Take-up Packing Cups and Gaskets. Expander Rings.

CANADIAN JOHNS-MANVILLE CO. LIMITED

Montreal Toronto Winnipeg Vancouver

10 Factories Branches in 63 large cities

MADE IN CANADA

Factors That Increase Locomotive Effectiveness

FRANKLIN RAILWAY SUPPLY COMPANY OF CANADA, Limited

625 Transportation Building
MONTREAL

CANADIAN GOLD CAR HEATING & LIGHTING COMPANY, LIMITED

MANUFACTURERS OF

CAR HEATING APPARATUS OF EVERY DESCRIPTION

STEAM—VAPOR—COMBINATION—HOT WATER
ELECTRIC PRESSURE REGULATORS—VENTILATORS
THERMOSTATIC CONTROL FOR ALL SYSTEMS

346 ST. JAMES STREET. MONTREAL, CANADA.

Taylor & Arnold
LIMITED

Railway and Marine Supplies

MONTREAL WINNIPEG

WORKS:

100 ANN STREET, MONTREAL

All Canadian Railways use our **Standard Steel Platform**

When they realize the merits of our

SESSIONS-STANDARD FRICTION DRAFT GEAR

They will ALL use it (some do now)
It is daily growing in popularity

Both made by

STANDARD COUPLER COMPANY

30 CHURCH STREET, NEW YORK

FOR SALE

THE BALDWIN LOCOMOTIVE WORKS

Philadelphia, Pa., U.S.A.

STEAM, GASOLINE AND ELECTRIC

LOCOMOTIVES

Pyle-National Headlights

For Every Need

Type "K" - - 300-watt
Type "E-2" - - 500-watt
Type "E" - - 1500-watt
Type "T" - 2500-watt

THE PYLE-NATIONAL COMPANY

1334 N. Kostner Ave., Chicago, Ill.

Canadian Representative:

The Holden Company Limited

Main Office, 350 St. James Street Montreal, Que.

Sawn Lumber and Dimension Timber in Pine and Spruce
Car Sheathing, Roofing, Etc.

W. C. EDWARDS & CO., Ltd.

New Edinburgh Mills
OTTAWA - Ontario

Sawmills at
Ottawa and Rockland, Ont.

Factories and Planing Mills at
New Edinburgh Mills, Ottawa

KING METALLIC PACKINGS

for Locomotive Piston Rods, Valve Stems and Air Pumps

THE KING RING IS IN 2 PARTS ONLY

SIMPLE
SUBSTANTIAL
STEAM-TIGHT

The U. S. Metallic Packing Co.
PHILADELPHIA

Consolidation Type Engine built for the

CANADIAN PACIFIC RAILWAY COMPANY OF CANADA

BY THE

CANADIAN LOCOMOTIVE CO.

Limited

BUILDERS OF

LOCOMOTIVES

FOR ALL CLASSES OF SERVICE

KINGSTON, - - ONT.

WESTINGHOUSE AIR BRAKES

For Steam and Electric Railways

AMERICAN
AUTOMATIC SLACK ADJUSTERS

Air Compressors, Electric Locomotives and Electrical Apparatus of every description

BUILT FOR THE DOMINION BY

CANADIAN WESTINGHOUSE CO., Limited

General Office and Works: HAMILTON, ONT.

MONTREAL, TORONTO, HALIFAX, VANCOUVER WINNIPEG, CALGARY
OTTAWA (Ahearn & Saper, Ltd.) FORT WILLIAM

ADDRESS NEAREST OFFICE

FOR SALE

"Golden Glow" Locomotive Head Lights
Demountable Mirror Units and
Keystone Turbo-Generators

ARE DIFFERENT AND DECIDEDLY BETTER.
MAY WE SHOW YOU HOW AND WHY?

LYMAN TUBE & SUPPLY CO., Limited
MONTREAL TORONTO WINNIPEG NEW YORK

H. A. DRURY CO., Limited
MONTREAL — TORONTO — NEW YORK

SABEN
AND
SABEN EXTRA
HIGH SPEED STEELS

B. J. COGHLIN CO., Limited
Manufacturers of
Springs, Track Tools,
:: Railway Supplies ::

OFFICE AND WORKS:
Ontario Street East - Darling and Davidson Streets
MONTREAL

A Trade Mark is known by the Company it Keeps—by the Service that Company Gives—and by the Quality of its Goods.

★

CANUCK FRONT END PAINT

Canadian Railway Club

INCORPORATED

Official Proceedings

Officers, 1919-20

President:

Mr. J. HENDRY,
General Master Car Builder,
G.T.R., Montreal.

First Vice-President:

Mr. W. H. WINTERROWD,
Chief Mechanical Engineer, C.P.R.,
Montreal.

Second Vice-President:

MR. C. H. N. CONNELL,
District Engineer, Can. Natl. Rlys,
Quebec.

Executive Committee:

MR. A. CRUMPTON,
Valuation Engineer,
G. T. R., Montreal.

MR. E. A. NIX,
Montreal

MR. B. F. SHORTLEY,
Terminal Agent, Can. Natl. Rlys.,
Montreal

MR. E. R. BATTLEY,
Supt. of Motive Power, Eastern
Lines, G. T. R., Montreal

MR. R. A. PYNE,
Supt. of Motive Power, C.P.R.,
Montreal

MR. W. H. SAMPLE,
Genl. Supt., Motive Power & Car Depts.,
G. T.R., Montreal

Audit Committee:

MR. W. H. LANGRIDGE,
Auditor Disbursements, Angus Shops,
C. P. R., Montreal

MR. G. M. WILSON,
Supt. Motive Power, Point St.
Charles Shops, G. T. R.,
Montreal.

MR. R. H. HARVEY,
Representative Sasety Car Heating
& Lighting Co.,
Montreal

Secretary:

MR. W. A. BOOTH,
Engineer of Locomotive Construction,
G. T. R. Montreal.

Treasurer.

Mr. E. E. LLOYD,
Audit of Disbursements,
C.P.R., Montreal

Past Presidents:

Mr. E. A. WILLIAMS,
259 Ridgewood Ave.,
Glen Ridge, N.J., 1903

MR. T. McHATTIE,
12 Windsor Ave.,
Westmount, 1904

Mr. S. KING,
870 Queen's Ave.,
London, Ont., 1905-06

Mr. W. E. FOWLER,
941 Beacon St.,
Los Angeles, Cal., 1906-07

Mr. W. D. ROBB,
Vice-President, G.T.R.,
Montreal. 1907-08.

Mr. L. R. JOHNSON (deceased),
Montreal. 1908-09.

Mr. H. H. VAUGHAN,
Vice-President Dom. Bridge Co.
Ltd., Montreal, 1909-1910

Mr. A. A. MAYER,
1000 Tupper St.,
Montreal. 1910-11

Mr. A. A. GOODCHILD,
General Storekeeper, C.P.R.,
Montreal, 1911-12.

Mr. J. COLEMAN,
Supt. of Car Department,
G.T.Rly., Montreal, 1912-13.

Mr. R. W. BURNETT,
Vice-President Natl. Car Equip-
ment Co., Chicago, 1913-1914.

Mr. W. McNAB,
Chairman, Valuation Committee,
G.T.R., Montreal, 1914-1915.

Mr. LEWIS C. ORD,
Asst. Works Manager, C. P. R.
Angus Shops, Montreal, 1915-1916

MR. R. M. HANNAFORD,
Asst. Chief Engineer, Montreal
Tramways Co., Montreal, 1916-17.

Mr. G. E. SMART,
Genl. M. C. B., Can. Nat. Rly.,
Toronto, 1917-1918

MR. C. W. VAN BUREN (deceased)

MR. T. C. HUDSON,
Gen. Master Mechanic, Can. Natl. Rlys.,
Montreal., 1918-19

Published every month, except June, July and August, by the
Canadian Railway Club.
W. A. BOOTH, Secretary, 131 Charron Street, Montreal.

Vol. XIX. No. 3 **Montreal, Can., March 9, 1920** 25c. per copy

PROCEEDINGS OF THE CANADIAN RAILWAY CLUB.

Windsor Hotel,
Montreal, March 9th, 1920.

Chairman (Mr. J. Hendry) :—

Come to order, gentlemen, please. The first order of business is signing of the cards which you will find in the seats. Next is the reading of the minutes of previous meeting. These have been printed and are being mailed you. It will not, therefore, be necessary to read them. We will now pass on to the next item which is the reading of applications for membership.

Secretary :—

I am sorry that we have not got a larger list of applications to-night, but it is probably due to the fact that we are reaching the end of our club year. I have pleasure in submitting the following applications, however, which have already been passed on by your Executive Committee.

New Members

F. Acthenson, Chief Engineer, Place Viger Hotel, 2034 20th. Ave., Rosemount, Montreal.

Aubrey A. Burrows, Business Manager, Canadian Railway & Marine World, 70 Bond Street, Toronto, Ont.

W. Casey, General Manager, Canadian Locomotive Company, Kingston, Ont.

John J. Coleman, Can. Mgr. Thos. Firth & Sons, Ltd., 449 St. Paul Street W., Montreal.

Albert Ineson, Erecting Shop Foreman, Canadian Pacific Railway, Angus Shops, Montreal.

J. W. Kennedy, Gen. Supervisor of Car Piece-work, C. P. R., Angus Shops, Montreal,

W. S. Lowe, Senior Clerk, Aud. of Disbursements, Canadian Pacific Railway, Montreal.

W. H. McCready, Ch. Clerk, Operating Dept., Can. Car & Foundry Co., Turcot Works, Montreal.

Wm. Oliver, Boiler Shop Foreman, Canadian Pacific Railway, Angus Shops, Montreal.

Chairman:—
Gentlemen, you have heard the list of applications for membership. What is your pleasure?

Mr. W. H. Sample:—
I move they be accepted.

Mr. R. Crawford:—
Seconded.

Chairman:—
It has been moved by Mr. Sample, seconded by Mr. Crawford, that these applications be accepted. All in favor. Carried.

MEMBERS PRESENT

Hendry, J.
Allan, A.
Baxter, J. A.
Beahan, J. P.
Bermingham, T. C.
Boaz, Geo.
Boughton, L.
Bradley, J. E.
Brady, P. P.
Brooks, P. A.
Brown, D. M.
Buckland, A. W.
Buckle, W. E.
Burns, E. W.
Burns, J.
Campbell, M. M.
Chown, T. C.
Clark, W.
Coleman, M. T.
Comley, W. T.
Crawford, R.
Crawford, R. E.
Crutchlow, Geo.
Cunningham, E. A.
Curtiss, T. H.
Cuss, T. C.
DeAngelis, G.
Dicken, J. H.
Dohm, J. T.
Donnelly, M. R.
Duchesne, E.
Dunlop, J. B.
Dyke, H. J.
Edwards, B.
Foster, J.
Gregory, W. A.
Harrison, E. V.
Hawes, W. T.
Hicky, J. V.
Hobart, E. P.
Holland, N.
Horn, B. T.
Hudson, T. C.
James, H. H.
Jarman, T. S.
Lachapelle, J. D.
Lloyd, E. E.
Ludington, W. H.
Macdonald, H. G.
McDonald, A.
Mackie, R. L. D.
MacVicar, R.
Martin, C.
McGinnes, C. P.
McMillan, E. S.
McNown, W. L.
Meissner, O. W.
Moore, F. W.
Moore, T. H.
Morrison, L.
Needham, R. J.
O'Brien, E.
Ord, L. C.
Oshmera, J. F.
Payne, H.
Phillips, F.
Pope, A.
Powell, J.
Prowse, W.
Riddington, A.
Robertson, A.S.,Jr.
Robinson, H. A.
Rodgers, J. H.
Sample, W. H.
Sawyer, E. M.

Sleigh, T.	Thomas, E.	Williams, L. A.
Smith, E. D.	Thorburn, C. D.	Winship, R. B.
Spence, J. M.	Thorp, H. W.	Young, O. W.
Spence, W.	Tinkler, J. E.	Booth, W. A.,
Stewart, W. F.	Watkin, B.	
Symmes, H. H.	Whyte, G. P.	and others.
Tetlaw, H.	Williams, F.	

Chairman:—

Before calling upon the speaker of the evening we have a pleasant function to perform, and I will call upon Mr. L. C. Ord to come forward, and in this connection I will also ask Mr. T. C. Hudson, one of our past presidents, to say a few words.

Mr. T. C. Hudson:—

Mr. Chairman and Members, as you are aware, it has been customary in the past, when a President of this Club retires from office at the end of the club year, to present him with the Past President's Jewel, emblematic of the office. Mr. Ord, a past president, went overseas in the service of his country before his term as President was completed, and was absent when his successor was elected to office; therefore, we did not have a suitable opportunity to follow out our usual custom in his case.

Mr. Ord, the Officers and Members of this Club take great pleasure in now presenting you with this Past President's Jewel, as a mark of their appreciation for you and your services in connection with the Club, in accepting it, we hope that when you wear it in the days to come, it will be with many pleasant recollections of Canada and your association with us.

We just learned to-night, that it is your intention to again go overseas to reside, this time in a business capacity, and while we are sorry to lose you from the club, we are glad to know that you are improving your position.

To your wife and family we extend our good wishes and trust you will be spared many years of enjoyment together, and to you the best of good luck in your new venture and God-speed on your way. Applause.

Mr. L. C. Ord:—

Gentlemen, the biggest regret that anyone would have in leaving as I am doing is the friends he is leaving behind.

—other conditions do not count. Some of you here have known me since I was a youngster in petticoats, and the teaching I have had, and the knowledge gained, has been largely under the supervision of some of the older members of this club. This club does function on one thing probably more than anything else and that is the assistance it extends to its younger members to take part in its discussions. I can well remember the first efforts I made to get up and speak at our meetings, and while these efforts were somewhat nervous they always met with such ready encouragement that it was impossible not to feel the sympathy and hearty support that was being accorded. When the club was first talked of—I think it was Mr. Giroux who thought it would be well to meet periodically at which meetings official position would not be considered but a full interchange of views take place and good fellowship promoted. It is the breaking away from this fellowship that is my one regret in undertaking this new adventure, and I want to thank you all heartily and sincerely for the help and encouragement I have had from the members of the club, both while a member and while in the Chair as President. I think I am one of the oldest members. I thank you again for your kindness and especially for this mark of esteem which badge I will wear proudly in the future.

President:—

We have with us to-night Col. Minden Cole, who has a few words to say to us. We should like to hear from him now.

Col. F. Minden Cole:—

Mr. President and members of the Club. It was only this afternoon that I learned of Major Ord's intention to return overseas, and this was the only opportunity I had of seeing him before his departure. I have been invited to attend your meeting—although not a member of your Club —and I wish to thank you, Mr. President, for this opportunity to say a few words.

I had the privilege when in France of commanding all the Canadian Siege and Heavy Batteries, and some twenty odd British and South African Batteries. When I left Canada my junior officer was Lieut. Ord. We went first to a British camp for the technical training that would best fit us for the work ahead of us. The Commandant of the

Camp, General Lyle, one day pointed out Lieut. Ord on the field, says, "I don't know that officer's name, but he is one of your brightest subalterns; I know it by his work and by the questions he asks in the class rooms." From orderly officer Lieut. Ord worked his way up, until in France he became a Battery Commander.

I remember, in the work before Vimy he trained his battery until it was firing twelve hundred 290 lb. shells in 24 hours. That quantity was afterwards exceeded but it held the record at the time. It was just the job that a railroad man could handle better perhaps than anyone else. Another incident I recall, after we took Vimy Ridge, which we had been bombarding for twenty days previous to the attack, our General said he was sorry we could not reach certain points to which the enemy had withdrawn, that all our guns were firing "below range table." You probably know that the range of a Howitzer decreases rapidly when constantly in action. I assured the General that the guns of one battery were still firing up to the ranges given in the range tables. This was the case, and the battery was the one of which Ord was the Captain. In my opinion his technical training enabled him to watch his guns closely and keep them in good shape, whereas the man without such experience would keep on firing until the guns would have to go back to the field workshop for repairs. After the taking of Vimy I received a letter from Brig.-General Odlum to whom Capt. Ord had been sent to co-ordinate our work with that of the infantry. If I can find that letter I am going to hand it to him, as it is a tribute to his efficiency. He worked with his accustomed energy right up to the end of the war, and I am glad that with all the risks he came through safely.

There is another side to his character. He came to me at headquarters one day with the news of the death of one of his young officers, and he was so affected he was hardly able to speak. The young officer was Lieut. Kay, of Montreal, a fine clean cut young Scotchman, who had risen to be sergt.-major and then won his commission. The day I refer to the Battery was being heavily shelled. Kay hustled his men under cover and while seeing that his men were safe he was struck by a piece of shell and died shortly afterwards.

The position Major Ord is about to fill overseas has possibly come to him as the result of his record becoming

known to prominent business men in England, who have heard of him as an efficient artillery officer.

Chairman:—

Gentlemen, the next order of business is the reading of the paper prepared for this evening on "Valve Motion—A Few General Observations," by Mr. F. Williams, Mechanical Designer, Canadian National Railways, Moncton, N.B.

In asking for a paper on Valve Motion, your Committee has certainly given me plenty of scope, and I mean to take advantage of the liberty given me by lightly touching different points over a considerable range of the subject, with the hope that I may hit upon some of your pet theories and thus start a discussion which may be interesting and beneficial to all of us.

The duties which a locomotive valve gear has to perform are exacting in the extreme, as it has to control the distribution of steam to the cylinders with almost perfect precision through a wide range of cut-offs in forward and reverse direction. There is no apparatus on a locomotive upon which the economical working depends so largely, and when we consider that at diameter-speed the movement of the distribution valve is reversed 672 times per minute, we can appreciate with what care the design must be undertaken.

From the point of view of economical steam distribution, valve motion design has to-day reached a point where it cannot be greatly improved upon, and the chief attention of the designer has for the last few years been taken up with questions of accessibility and low maintenance cost, his aim being to apply a gear which would run and keep square from shopping to shopping with the minimum of attention.

Considered from the stand-point of steam distribution alone, I doubt if a well designed and properly set Stephenson gear has ever been excelled, but owing to inaccessibility, high maintenance cost and its great liability to get out of square due to the springing of parts and development of lost motion, the Stephenson gear has become a back number, and I shall only refer to it for purposes of comparison.

For several years past practically every locomotive built in this country has been equipped with an outside gear, the vast majority with Walschaert's, and to this gear I shall devote most attention.

Of all locomotive valve gears made, Walschaert's is the simplest to understand, to design and to set, and when this gear has been well designed and correctly set, it will keep square for an indefinite length of time.

The simplicity of the gear lies in the fact that the valve receives its motion from two sources, first from the crosshead through the combination lever, and second from the eccentric through the link, and each of these sources of motion can be dealt with separately without considering the influence of the other, both in designing and setting.

The motion derived from the combination lever is equal to the steam lap plus the lead and it attains its maximum travel when the engine is on the dead centres, it is not affected in any way by the reverse gear but remains the same in all positions of the lever.

The motion derived from the link is simply a symmetrical motion front and back of the center line, and is increased or decreased according to the distance of the link block from the center of the link. When the link block is exactly in the center of the link there is, of course, no motion from this source and as the block gets by the center the motion is reversed. When the engine is on the front or back dead center the link assumes such a position that the reverse lever can be moved backward and forward through the entire travel without imparting any motion to the valve, and the distance the valve is off center is entirely due to the position of the combination lever which is at its maximum travel at these points.

The proportioning of the length of the combination lever is a simple matter when we have decided on the steam lap and lead required.

The length of the combination lever from the radius bar connection to the union link connection must bear the same proportion of its length from the radius bar connection to the valve stem crosshead connection as does half the stroke of the piston to the lap plus the lead plus 1/64". The 1/64" is added to the lap plus the lead to take care of lost motion.

Care must be taken that the length of the combination lever adopted will bring the lower end of the lever to the correct level to connect up with the union link, especially if the union link is connected directly to the wrist pin, which is the practice generally adopted unless the Ripken Kingan main rod arm is used.

With regard to the length of the radius bar and eccentric rod. I have seen various rules in print, but they are for the most part worthless, as our problem is to apply a gear to a

locomotive; we are not permitted to design a valve gear and then build an engine around it. The best rule we can adopt therefore is to make both the radius bar and the eccentric rod as long as circumstances will permit and with ordinary wheel bases this will invariably give satisfactory results.

The radius of the link slot center line is of course determined by the length of the radius bar and the preferred location of the link support bearings is such that the horizontal center line is on a level with the radius bar connection to the combination lever. This location may be varied within reasonable limits without affecting the valve events to any appreciable extent; for instance, on a locomotive with a very large cylinder the steam chest center line and the cylinder center line are of necessity quite a distance apart and in this case the link support is sometimes lowered an inch or two to bring the link tail nearer to the horizontal center line of the axle.

The angle through which the link rocks should not exceed 45°, and if it can be kept lower so much the better.

The eccentric rod connection to the link tail should be kept within 3″ or 4″ of the horizontal center line of the axle in order to keep the angularity of the eccentric rod within limits and owing to this angularity of the rod, it will be found necessary to offset the tail connection of the link in order to give it the same angular travel on either side of the central position. I have heard men with a good deal of experience state that an approximately correct offset is all that is required, but as it is just as easy to make this offset correct as otherwise I always prefer to make it dead right.

The eccentric crank must be set so that it brings the link dead on its central position when the engine is on either front or back dead center and the throw of the eccentric pin must be such that, acting in combination with the radius of the link tail, it will give the required angular travel to the link.

The reverse shaft location, length of arm, and swing link are very important considerations, and unless great care is exercised in the arrangement of these details the efficiency of the motion may be considerably reduced. The arc which the reverse shaft arm describes should be so arranged as to reduce the link block slip to a minimum in all positions of the reverse lever, special attention being paid to the running position in fore gear.

It is impossible to avoid link block slip altogether, but it can be kept pretty low, and if this is not carefully looked

after the effect will be seen in the valve events and also in the wear on the link and link block.

The steam chest center line should be outside the cylinder center line far enough to permit of bringing the whole motion into practically a straight line, thus eliminating the necessity for rockers and doing away with the twisting effect and lost motion which the use of rockers involves.

All road engines equipped with Walschaert gear should be so arranged that the link block is in the bottom half of the link for fore gear, the eccentric of course following the crank pin. The advantages of this arrangement are that the wear on the link support bearings is diminished and the link block slip in running position may be kept very small, as the swing link describes an arc which is very similar to the arc struck by a point in the bottom of the link, the concave side of both these arcs being uppermost.

It is very important that the design of this gear should be as good as it is possible to make it, for if it is faulty, it is impossible for the valve setter to correct its faults. With a badly designed Stephenson gear a good valve setter could often get very fair results in running position by sacrificing the other positions of the reverse gear, but with a Walscheart gear this is out of the question, as this gear is squared on the dead centers, and if the design is good all the valve events naturally come within very close limits of being square, but if they do not there is practically nothing the valve setter can do to correct them.

It must be borne in mind that the chief aim of the designer is to obtain as nearly as possible a perfect steam distribution, but the most important consideration with the valve setter is to get four level beats up the stack. A perfect steam distribution will of course give a perfect exhaust, but a perfect sounding exhaust does not necessarily mean a perfect steam distribution by any means. The steaming properties of the boiler and the fuel economy depend very greatly on the evenness of the exhaust, and if the exhaust is ragged the vacuum in the smokebox is unsteady and the fire is soon pulled in holes, resulting in a great waste of fuel. The designer therefore endeavors to obtain a perfect exhaust by giving as nearly as possible a perfect steam distribution, the valve setter has to get an even exhaust at all costs.

The normal setting for a Walschaert gear is square on dead centers with a constant lead in all positions of the reverse lever, but there is another setting which is sometimes resorted to and this is to give no lead at all or a very slight

lead in full fore gear and an increasing lead as the lever is notched up toward mid-gear.

This variable lead is a feature which is natural to the Stephenson gear with open rods and this gear was commonly set with no lead in both fore and back full gear, but in notching up from either of these positions an increasing lead was obtained. It is not a natural feature with the Walschaert gear, however, and if we produce it in the fore gear we do so at the expense of the back gear.

A prevalent idea seems to be that it is detrimental to have any lead at all in full gear as it hinders the starting of the engine, some text books also tell us that the object of lead is to cushion the piston at the end of its stroke. If we study the question closely we will agree, I think, that both of these arguments are incorrect. Lead cannot hinder starting unless the admission takes place considerably before the piston completes its stroke, and as a matter of fact the pre-admission in full gear is so small that it can hardly be measured; as for lead cushioning the piston, a glance at a few indicator cards will show us quite plainly that compression and not lead has to take care of this.

The main object of lead is to give an unrestricted supply of steam to the cylinder when the piston begins its stroke and with the pre-admission down to about 1/64" it is impossible that the steam admitted to the cylinder can exert any appreciable turning moment on the axle until the crank pin has gone over the center.

Although the lead is constant on a normally set Walschaert gear the pre-admission increases as the lever is notched up, so that if the cushioning effect of the live steam is really required, we have this effect increasing as the lever is pulled towards mid-gear. I do not pretend to say that the pre-admission increases to the same extent as on a Stephenson gear but then I think it is generally admitted that the pre-admission is high on this gear in running position. The real object of setting the Stephenson gear with no lead, or 1/16" or so blind, in full gear, was not to overcome the detrimental effect of lead in full gear, as this is non-existent, but to bring the closure point to such a position that the compression would not be excessive when running at high speeds, so that if this variable lead setting with Walschaert gear is justified it is through its influence on the other valve events such as cut-off, release, closure, etc., as the lead itself has no influence one way or the other in starting.

We will now take a look at the valve diagram shown in Figure 1, plotted for one of our large passenger engines. This engine has 24″ x 28″ cylinder, a 14″ valve, 6″ valve travel, ¼″ constant lead, 1—1/16″ steam lap and ¼″ exhaust clearance.

The broader ellipse in the center shows the valve travel in relation to the piston travel in full fore gear, and the narrow ellipse inside it shows the same thing with the lever notched up to a 25% cut-off. The distance from the steam edge to the exhaust edge on the valve over the packing rings is 2¾″, therefore the similar ellipses which are plotted 2¾″ above and below the center ellipse with lighter lines must represent the movement of the exhaust edges of the valve. The three ellipses shown in dotted lines represent the movement of the valve set with no lead in full fore gear.

Picking out the valve events we find that with the ¼″ lead setting we have the cut-off at 23″ and 23⅞″, the release at 25 9/16″ and 26¼″ and the closure at 26 13/16″ and 27¼′.

Set with no lead however we have the cut-off at 23 9/16″ and 24⅝″, the release at 26⅛″ and 26¾″, and the closure at 27¼″ and 27⅝″, so that the net result of adopting this latter setting is to delay the cut-off from 83.7% to 86.1%, the release from 92.6% to 94.5% and the closure from 96.6% to 98%, an improvement in the starting position of 2.4, 1.9 and 1.4 per cent of the stroke respectively.

The valve diagram shown in Figure 2 is plotted for the same engine in full back gear, the ellipse shown in dotted lines representing the valve movement with the variable lead setting. In this case I have two lines ¼″ above and below the center line representing the amount of the exhaust clearance; these lines will determine our release and closure points in the same way that the outside edges of the steam ports did in Figure 1, and will simplify the diagram.

A glance at this diagram will show us that the cut-off, release and closure points are advanced in backgear by just about the same amount as they were delayed in fore gear, so that whatever we have gained in the foregoing position we have done so at the expense of the back.

In the short cut-offs there is so little difference in these two settings that I have only plotted one which I mentioned before when alluding to Figure 1.

Before we can realize exactly how much or little advantage is to be gained by this variable lead setting in full fore gear, we shall have to analyze the situation a little further and go into the question of starting tractive effort.

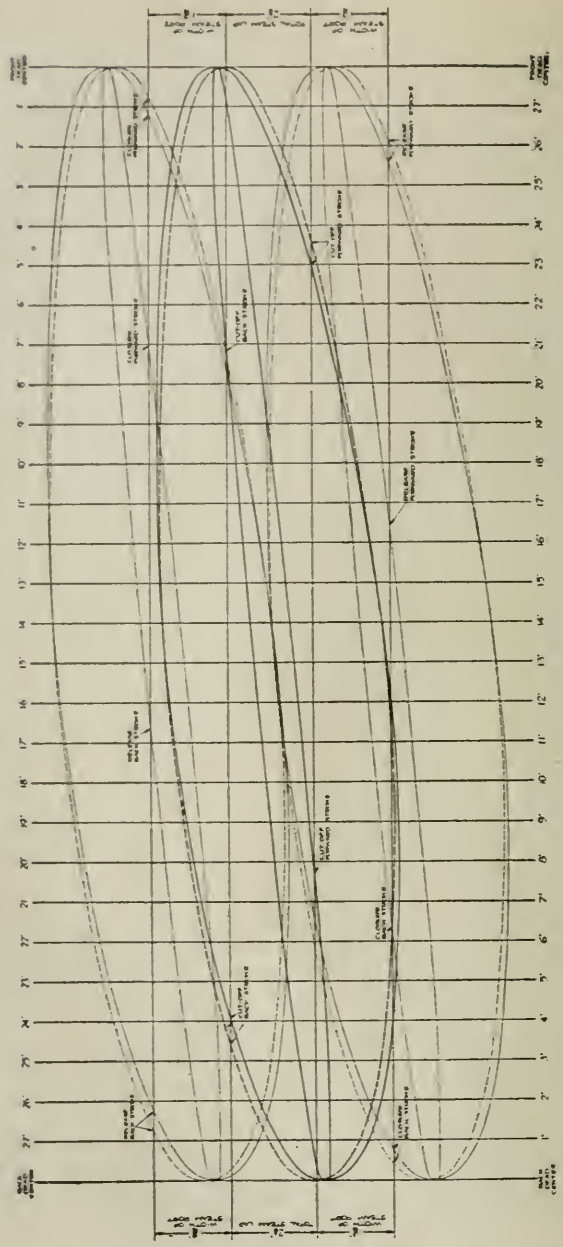
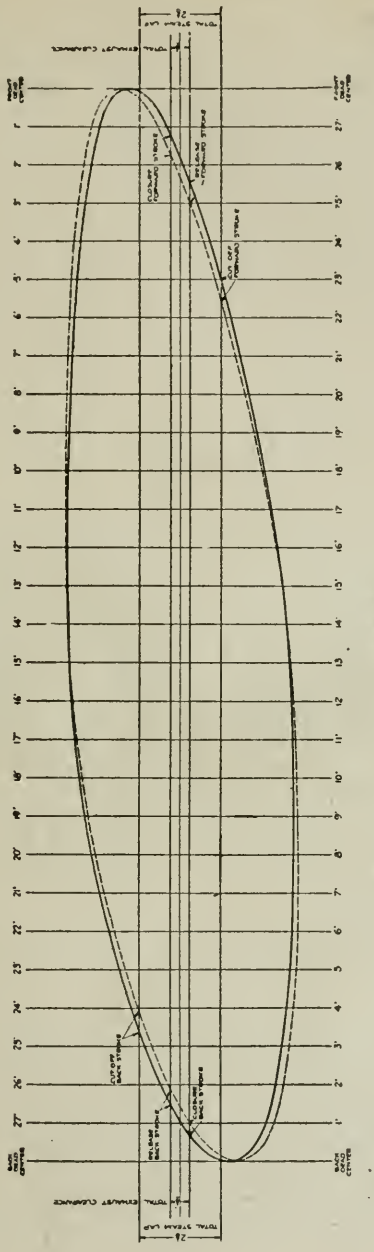


FIGURE I.



VALVE DIAGRAM.
FULL BACK GEAR.

FIGURE 2.

We all know that the worst starting position for a locomotive is when she is standing with one side just past the cut-off point. In this case the whole starting effort has to come from the other cylinder where the crank has not yet reached the point of maximum leverage.

Figure 3 shows the position of the crank pin of this engine at the point of cut-off, the full line indicating position with normal setting and the dotted line with the variable lead setting. It is evident that when the engine is standing in this position we shall get the minimum starting effort, as all the turning moment has to come from the other crank, which will be either at B b or C c, according to whether A a represents the right hand crank or the left. The effective length of the crank, which is doing the work, is 10″ for nominal setting and 10⅝″ for the variable lead setting, or a difference in favor of the variable lead of 6¼%, so that we may say that the minimum starting effort of this engine is increased 6¼% by this setting.

I do not wish to convey the impression that this engine can be improved 6¼% by this means, as the maximum tractive effort is not affected in any way, and the only advantages are that the maximum tractive effort is available through a very slightly wider range of positions, and in the very worst starting position the tractive effort is increased by 6¼%.

As soon as the engine has turned a wheel the advantage almost entirely disappears, the slight delay in the release and closure points may result in a slight improvement during the early stages of acceleration, but on notching up the two settings are practically identical.

Figure 4 shows a diagram plotted for one of our Mikado engines. This engine has a 27″ x 30″ cylinder, 14″ valve, 6½″ valve travel, ⅛″ constant lead, 1″ steam lap and no exhaust clearance.

The chief difference from the passenger engine settings are reduced lead, reduced steam lap, and elimination of the exhaust clearance.

We have already seen that reducing the lead will give us a later cut-off in starting position and have decided, I think, that this is an advantage when starting the load. Reducing the steam lap has the effect of lessening the period of expansion, but by reducing the exhaust clearance the period of expansion is lengthened and thus the ill effect of cutting down the steam lap is neutralized.

The reduction or total elimination of the exhaust clearance lengthens the period of expansion by delaying the release, and

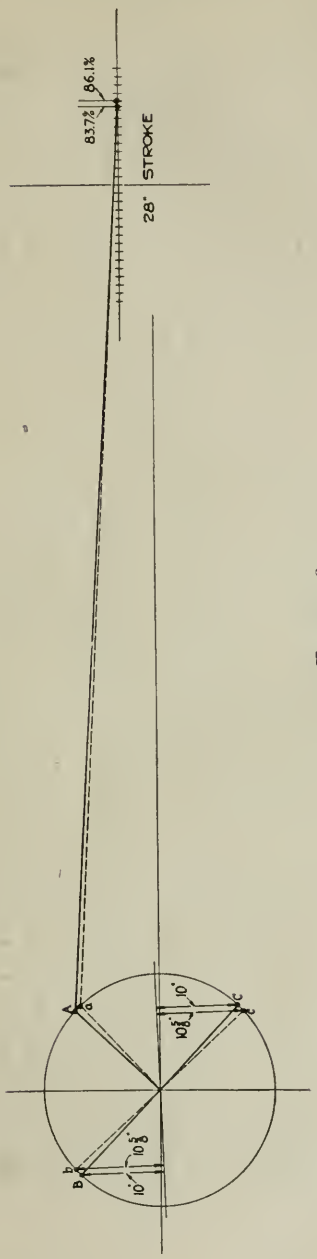


FIGURE 3.

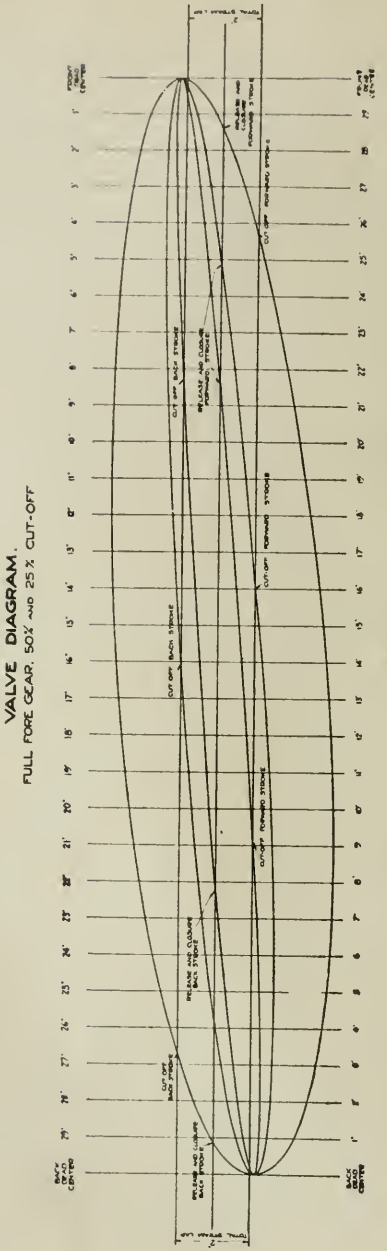

VALVE DIAGRAM.
FULL FORE GEAR, 50% AND 25% CUT-OFF
CUT OFF BACK STROKE
RELEASE AND CLOSURE BACK STROKE
CUT OFF FORWARD STROKE
RELEASE AND CLOSURE FORWARD STROKE
BACK DEAD CENTRE
FRONT DEAD CENTRE

FIGURE 4.

this in itself is a good feature, but it has also the effect of advancing the closure point and the question naturally arises as to why it should be permissible to eliminate exhaust clearance and thus advance the closure point on freight engines and not on passenger engines.

The first reason is that in running position the passenger engine is generally notched up to a much earlier cut-off than the freight engine—about 25% of the stroke instead of 50% —and the second that the piston speed of the passenger engine averages much higher than that of the freight engine.

The passenger engine, under consideration, has a piston speed of 1136 feet per minute when making 50 miles per hour, or over 40% higher than that of the freight engine at 30 miles per hour, and the higher the speed the higher the compression will be, provided that all other conditions are equal. It is a mistake to think that compression always starts from the closure point, it does at very slow speeds, but as the speed increases the compression begins earlier, owing to the fact that the piston has to sweep a considerable volume of steam through a port opening which is narrowing down for the closure, in an increasingly short space of time.

By giving this engine exhaust clearance we not only delay the closure point but also give a greater exhaust port opening, thus allowing the exhaust freer access to the atmosphere, and the result is a freer running engine.

You may say that when the engine is working at a short cut-off less steam is admitted to the cylinder, and, therefore, the piston has less to sweep out on the return stroke, but if we consider for a moment we shall realize that the exhaust begins with the release, and by the time the return stroke has begun there is very little difference in the amount of steam left in the cylinder, whether running on long or short cut-off.

When dealing with the question of compression we have to look into the matter from several different view-points.

From the point of view of economy of steam consumption per unit of power developed, the higher the compression the greater the economy, provided we do not run the compression higher than boiler pressure. This is on account of the clearance volume, and we can readily understand that the higher the compression the less steam has to be supplied from the boiler to build up the initial pressure, and if the compression reaches boiler pressure there is no steam drawn from the boiler until the piston actually starts its working stroke.

The next thing to consider is the power required, as it is no use trying to run on a very fine thread of steam if we can-

not get the tractive effort necessary to keep the load moving. From this aspect of the question, compression is negative effort, and a high compression curve seriously cuts down the area of an indicator diagram and the mean effective pressure, thereby reducing the power delivered.

The third and most important consideration is machine friction, and this generally limits the compression in practice. When the compression is too high it can generally be detected in the cab, as the engine will jig and ride badly at high speeds, and the effect on the rods and other running gear will be disastrous if this condition is allowed to continue.

If we compare Figures 1 and 4 we find that the closure takes place at 76% of the stroke for the passenger engine in running position; with the freight engine running at the same cut-off the closure takes place at 73%, but if we eliminate the exhaust clearance on the passenger engine we shall advance the closure point from 76% to 68% of the stroke.

This goes to show how much the closure point is affected by the amount of exhaust clearance. For my own part I do not think the actual closure point is of very much importance, but that the exhaust port opening has a great deal more influence on the compression than the actual position of the closure point. I contend that if we pay proper attention to the exhaust port opening the closure point will take care of itself.

There is no purely mathematical means of determining the most desirable exhaust port opening, and this, like so many other problems in locomotive work, has had to be determined by practical experiments.

It is here that we find the chief difference between passenger and freight engine setting, and, still referring to Figures 1 and 4, we see that the maximum exhaust port opening in running position for the passenger engine is just over 1⅝", whereas that of the freight engine is just over 1 9/16" when running at a 50% cut-off, while if we notch up the freight engine to the same cut-off as the passenger engine we have a maximum exhaust port opening of only 1¼".

This maximum port opening is only maintained for a few inches of the stroke, and it is easy to understand that when this port opening begins to narrow down it will form quite a choke for the exhaust at a high piston speed, and will build up quite a little compression before the closure point is reached.

We all realize that a locomotive exhaust has to be choked to a certain extent to obtain a high velocity jet up the stack

which will induce a proper draft through the grates, but this choking should be done by the exhaust pipe tip and not by the valve. Any choking which is effected by a correct exhaust pipe tip can build up but very little back pressure in the cylinder, whereas the throttling of the exhaust by the valve builds up considerable back pressure, and its effect on the draft is only detrimental.

The area of the bore of the exhaust pipe tip on the passenger engine under consideration is about 23 sq. in., and on the freight engine 29 sq. in., and the valve displacement necessary to give a port opening equal to the area of the tip will be approximately 11/16″ for the Pacific engine and 7/8″ for the Mikado. This 11/16″ port opening you can see from the diagram is maintained for 53% of the stroke on the Pacific engine, but on the Mikado the 7/8″ port opening is only maintained for 36% of the stroke when notched up to the same cut-off as the Pacific. When the Mikado is running at a 50% cut-off, which is approximately her running position, the 7/8″ exhaust port opening is maintained for 58% of the stroke, which compares favorably with the Pacific.

I think that this gives us the chief reason why the Pacific setting is found to be more suitable for high speeds and short cut-offs, while the Mikado setting is better on the slower speeds and long cut-offs.

We will now sum up the chief differences between passenger and freight engine settings, and as far as possible the reasons for the variation.

The passenger engine has a greater lead, which gives an unrestricted supply of steam to the cylinder at the beginning of the stroke and reduces the wire-drawing of the steam at high piston speeds. It has also the effect of increasing the exhaust port opening, which we will at once realize when we consider that the exhaust port opening at the end of the stroke must always be equal to the sum of the steam-lap plus the lead plus the exhaust clearance, so that the greater any of these three properties are the greater by that amount is the exhaust port opening at the end of the stroke.

The freight engine has a smaller lead in order to get a slightly later cut-off which will increase the starting effort, and as this engine works at relatively lower speeds it is not subject to wire-drawing to nearly the same extent as the passenger engine.

The passenger engine has a greater steam lap which lengthens the period of expansion and also increases the exhaust port opening, as explained before.

The freight engine has a smaller steam lap which allows a slightly later cut-off in full gear, and though it tends to cut down the period of expansion a little, the ill effect is neutralized by the reduction or total elimination of the exhaust clearance.

The passenger engine has a greater exhaust clearance which hastens the release and delays the closure point, but what is more important, it increases the exhaust port opening the amount necessary to keep the compression below the limit which will give a smooth running engine at the high speeds at which it has to work.

The freight engine has little or no exhaust clearance, which has the effect of delaying the release, which is an advantage. It also has the effect of advancing the closure point and restricting the exhaust port opening, but there are no ill effects to be found from this at the long cut-offs and relatively slow speeds at which this engine works.

From this comparison we can see that the passenger engine setting has been developed to give a smart and free running engine at high speeds and short cut-offs, while the chief consideration with the freight engine setting is to obtain the greatest possible tractive effort at moderate speeds and to run on comparatively long cut-offs with the greatest possible economy by delaying the release point as far as possible.

In conclusion, I wish to express my gratitude to Mr. Appleton for the help he has given me in getting out this paper, both in the way of suggestions and in affording me opportunities of taking readings from the actual locomotives.

Chairman:—

We have listened to a very good paper from Mr. Williams on this important subject. The meeting is now open, and we should like to have a good discussion.

Secretary:—

I want to emphasize what our President has said about this being an excellent paper. From a Motive Power point it is one of the best papers that has ever come before this club. I know a little about valve motion and consider that Mr. Williams has brought out some very good points. The paper states that the Stephenson link motion is a back number, and I think we have all to agree with him. On account of the increased size of the locomotives now being built it is not likely that any more motion of this type will be applied. We should not have to wait a moment for someone

to get up and speak on this interesting subject, and it should call forth a good discussion. We have here representative Motive Power men from all over Canada, and also some authorities on this question from across the border.

Mr. W. H. Sample:—

First of all I want to congratulate Mr. Williams on his paper. It is very nicely gotten up. Possibly some here who are more expert on valve motion than I am could criticize it, but I, for one, do not see how it could be put in a much nicer form, and I consider it is a credit to him and to Mr. Appleton. We have with us to-night some prominent valve men, and, if I am not mistaken in my observations, Mr. Young of the Young Valve Gear, is present. He is a wizard on this line of work, and I would like to see him get up and say a few words either for or against the paper which has been read.

Mr. O. W. Young:—

The subject of this paper is one which has occupied my mind for many years and it is refreshing to the extreme to hear a gentleman of Mr. Williams' experience and training expressing this evening the very fundamentals which I, too, have concluded must represent the premises upon which progress in the art of locomotive steam distribution should be based.

The Canadian Railway Club is to be congratulated on having in its annals a paper in which the salient features of this subject are so fully and, at the same time, simply expressed.

You will bear with me, I am sure, when I presume that many of the gentlemen present know something of my past and present activity in the development of methods for steam distribution; and a few notes which I have prepared will serve to indicate that, while separated widely by miles, the logic of the able writer of the paper you have heard and that of the speaker is the same.

The dynamic operation of a locomotive steam engine is accomplished by four essential acts; steam admission, expansion, exhaust and compression.

Admission.

Admission is the act of directing steam pressure against a piston. It is the motive agent employed for revolving the

wheels. The duration of the admission period must be subject to control by the locomotive engineer. At his option it should be possible to admit steam to the cylinders during nearly the entire piston stroke in order to insure positive starting reliability and maximum power for initial train movement. The maximum cut-off must therefore be late.

After starting a train it must then be possible to manually shorten cut-offs (the admission period), because less power is required to keep a train moving than is necessary to start and accelerate it, and because also, small volumes of steam must be used on account of difficulty of rapid exhaust after speeds become considerable, and further because it is impracticable to design locomotives with proper ratios between boiler capacity and cylinder volume to permit the use of full cylinder capacity only at low speeds. In addition, late cut-offs are uneconomical since they preclude effective expansion.

The range of duty required by a locomotive in starting, accelerating, attaining and maintaining high speed, is so great that it necessitates a wide range of cut-offs subject to control by an engine driver.

The admission period must begin as early as the beginning of a piston stroke. It may, and usually does begin before the completion of the piston's return stroke and that portion of its period is called pre-admission. Steam is then admitted against a piston tending to check movement and cushion its momentum. The pre-admission period should not commence before the crank pin is practically on a dead centre when working in late cut-offs and consequently slow speed. But it may, and it is desirable that it should begin considerably earlier when in early cut-offs (high speed position), because piston velocity is then greater and greater cushioning power needed to absorb the shock of checking and reversing the direction of piston movement.

It is desirable that during the admission period steam flow should be unobstructed in order that there may be but little drop in pressure against a piston up to the point of cut-off.

Any valve actuating mechanism tending to increase the widths of steam port openings is therefore for that purpose basicly sound.

Expansion.

Expansion is the act of prolonging steam pressure against a piston after admission ceases. A mass of steam then in a

cylinder cut off from further replenishment from a boiler, continues to expand and propel a piston with decreasing pressure until it is permitted to escape to the atmosphere. All piston movement during this process causes rotative impulse to the driving wheels without further drain on a boiler and is in the direction of fuel economy. The expansion period should therefore embrace the greatest practicable portion of piston movement. In all successful valve gears the relative duration of the expansion period increases with shortened cut-offs.

Expansion should be continued as late in the stroke as possible, and any valve gear that permits this, is in this respect desirable, provided it does not introduce objectionable features affecting other events in the cycle.

Exhaust.

Exhaust is the act of relieving a cylinder of pressure. Its period may be divided into two stages. First, after expansion has been carried as late in the stroke as practicable, all steam tending to propel a piston should be permitted to escape to the atmosphere. Unobstructed means should be provided for escape to the lowest obtainable pressure by the time a piston has reached the end of a stroke so as to insure the least possible initial back pressure during the return stroke. This is particularly desirable at high speed, because it is not only then more difficult to accomplish, but the piston speed is then so great that it precludes material lowering of back pressure ahead of the advancing piston during this, the second exhaust stage.

A valve gear therefore that causes rapid valve opening during the first exhaust stage, and maintains liberal opening during the second stage, not only increases effective cylinder pressure, but the increased power is produced economically because of lower negative pressure.

Compression.

Compression is the act of building up pressure to cushion a piston at the end of its stroke. Compression together with pre-admission serve to fill the clearance space between the piston when at either extreme position its nearest cylinder head and valve. These together insure high initial pressure.

All steam pressure remaining in a cylinder at the beginning of compression, together with 15 lbs. atmospheric

pressure, are concentrated into smaller space and should then approximate steam chest pressure. Compression and pre-admission blend into a common pressure. Compression costs only to the extent that it retards wheel revolution. Pre-admission costs in addition the amount of steam it draws from a boiler. Therefore, the terminal pressure should be largely caused by compression. That is, terminal compression should be so high that it will require but little if any additional pressure from pre-admission to build up a pressure equal to that in a steam chest. Compression should and does in all successful valve gears begin earlier at high speed (in short cut offs) than at low speeds. But at low speed terminal compression is lower and the influence of pre-admission more pronounced and expensive.

At high speed it is difficult to avoid excessive compression, and any valve gear tending to lower initial compression logically accomplishes some economy.

That Mr. Williams knows human nature is *most* evident when he said in introducing his subject, that he hoped he might get on some of our pet theories.

He did.

Conceding that "valve motion *has* to-day reached a point where it cannot be greatly improved upon" does it follow that we cannot consider the constantly increasing cylinder sizes which demand the rapid handling of greater volumes of steam and, consequently, more liberal means of handling this volume?

When 20" cylinders were the maximum in service the valve travel was 6", which was thought sufficient. An analysis of numerous tests with which this speaker is familiar showed excellent steam distribution in 20" cylinders with 6" travel and 12" piston valves. That combination is therefore used as a basis for the arguments herewith presented.

The first duty required of a locomotive in train operation is the start.

To insure this it is capable of demonstration by an analysis of main rod angles, and it is further proven by actual experience, that the maximum cut-off must be approximately 88% of the piston stroke. If of less than that percentage, a locomotive will frequently fail to start even though coupled to a comparatively light train, without first slacking back and not only reducing the initial load resistance, but also changing the crank and rod angles to more favorable leverages.

In order to provide for 88% maximum cut-off, the sum

of lap and lead must not exceed 19% of valve travel. A valve setting in the following tables is therefore so arranged.

Cylinder Diameters.	Sq. Inch Piston Area.	Valve Travel.	Lap and Lead 19% of Travel.	Lap.	Lead.	Valve Diameter.
20″	314	6″	1 9/64″	57/64″	1/4″	12″
25″	491	7″	1 21/64″	1 5/64″	1/4″	17″
30″	707	7″	1 21/64″	1 5/64″	1/4″	24″

Port Length.	Port Width 25% C.O.	Port Area 25% C.O.	Maximum Cut-off.
28.7″	9/32″	8″	88%
42″	19/64″	12.3″	88%
60″	19/64″	17.7″	88%

It will be noted in the table that for 20″ cylinders the piston area is 314 square inches, the valve diameter 12″ with 28.7″ port length exclusive of bridges, valve travel 6″, lap 57/64″, lead 1/4″, maximum port opening in 25% cut-off, 9/32″ which causes 8 square inches steam port area. This is equal to 1/40 of the piston area.

Assuming that a ratio of piston area to port area in 25% cut-off of 40 to 1 is necessary for rapid steam flow into a cylinder during admission, and assuming that the valve travel for larger cylinders is increased to 7″ with valve lap of 1 5/64″ and lead 1/4″ then for 25″ cylinders with 491 square inch piston area the port area should be 12.3 square inches. This would require a valve 17″ in diameter with ports 42″ long exclusive of bridges. 30″ cylinders with 707 square inches of piston area, 7″ valve travel, 17.7″ port area require valves 24″ in diameter with ports 60″ long.

Twenty-five per cent. is considered in the foregoing, because that is the desired running cut-off, as all valve events then combine to produce the best economy and efficiency.

Valve travel of only 7″ is mentioned, for the reason that with the Walschaert gear greater travel involves such acute angles in the movement of certain members of the gear that designing engineers have been reluctant to introduce them.

It is clearly shown that so far as the admission period is concerned, cylinders of 25 to 30" diameters require valves of 17 to 24" diameter to produce as free steam flow as 20" cylinders receive with 12" valves.

When it is considered that 16" valves are the maximum now in service and that there are very few in service in passenger locomotives of over 14" diameter, it is very evident that the larger cylinders are handicapped by insufficient port areas.

Cylinder Diameter.	Sq. Inch Piston Area.	Valve Travel.	Lap and Lead 19% of Travel.	Lap.	Lead.	Valve Diameter.
25"	491	9"	1 23/32"	1 11/32"	3/8"	11"
30"	707	9"	1 23/32"	1 11/32"	3/8"	16"

Port Length..	Port Width 25% C.O.	Port Area 25% C.O.	Maximum Cut-off.
26"	15/32"	12.3"	88%
38"	15/32"	17.7"	88%

Table No. 2 shows that with 9" travel 11" valves may be used for 25" cylinders and 16" valves for 30" cylinders and still retain a 40 to 1 ratio between piston and steam port areas in 25% cut-offs.

A valve gear arranged for 9" travel thus not only permits the use of smaller valves, but it may use valves now standard to large locomotives and greatly improve ratios between port and piston areas and thus insure very high initial pressure against the piston up to the point of cut-off, even at high speeds. As a result, it consequently has capacity to either haul heavier trains, or attain and maintain unusual speed, or both so far as the influence of admission extends.

If the sum of lap and lead is 19% of travel and the ratio between lap and lead the same, one gear with 7" travel and the other with 9" the duration in expansion periods in various cut-offs is alike, providing the exhaust setting is line and line in both cases but more exhaust clearance may be used with increased travel without relatively shortening expansion.

Due to the fact that steam is cut off at higher pressure because of more adequate port openings the piston pressure is higher during expansion period, particularly at high speed, and increasingly so for increased cylinder diameters than is possible with gears causing less valve travel.

It is evident, therefore, that increased power induced by improved admission caused by the gear with greater travel continues during the expansion period.

Initial pressure is applied to a piston at the beginning of its stroke. At that position all back pressure should have disappeared. The valve should have then caused the widest possible opening to the atmosphere. As the valve is displaced from its central position, the amount of lap and lead for the above piston position, and assuming that it is designed for line and line exhaust, the width then of exhaust opening is lap plus lead. Reference to the foregoing table shows that this is more than 3/8 of an inch greater in one case than the other, and this additional 3/8 of an inch in width of exhaust port opening obtains throughout nearly the entire exhaust period and in all cut offs. Due to its greater valve travel the exhaust port opens more rapidly in one case and it accomplishes decidedly wider openings during both exhaust stages.

Increased capacity is thus provided for rapidly expelling large volumes of steam. Rapid valve opening during the first exhaust stage vacates the cylinder to an unusually low initial back pressure and unusual width of exhaust opening during the return piston stroke further permits reduction in back pressure. This results in economically increasing effective pressure and further augments the cylinder power created by improved admission.

It logically follows then that with lowered back pressure, the pressure initially subject to compression is lower, and therefore lower terminal compression results, a further augmentation of cylinder power.

If the premise is sound on which this analysis is based it is confidently submitted that greatly increased valve travel with proportionately increased lap economically increases cylinder power.

1. By adequate steam port openings high pressure is maintained up to the point of cut-off.

2. On account of high cut-off pressure, expansive pressure is high.

3. Due to rapid and liberal exhaust port openings, ex-

haust is early and completely accomplished and low back pressure obtained.

4. Because of low initial compression, terminal compression is low.

The improvement accomplished in these four acts cause high positive pressure, low negative pressure, increased mean effective pressure and result in greater draw bar pull.

The practical operating benefits are positive reliability in starting; rapid acceleration; great hauling power, particularly at high speeds, capacity for unusually high speed and economical use of coal and water.

It is in the hardest service that these benefits are most pronounced and upon the largest locomotives that they attain their maximum valve for these benefits become relatively greater with increasing cylinder diameters.

Mr. W. H. Sample:—

I want to say, in connection with Mr. Williams' paper, and Mr. Young's address, that we have quite a few valve motions on the Grand Trunk. We have some splendid Walschaert valve motion, some splendid Baker motion and also some Young motion. They are all giving good service and I have no partiality to show particularly; but I would like to say, for Mr. Williams' engines, that he has some of the best Walschaert motion that I have ever seen. There are other gears besides those mentioned, the Joy, which I had considrable experience with in Costa Rica, and the Southern gear, which is used quite extensively in the United States. The first mentioned, or the Joy gear was applied to engines I have reference to in Costa Rica in 1885 and 1886, showing that the outside type of gear is not very new, but for some reason or other this type of gear was not adopted generally by American or Canadian railroads until within the last few years; but the dimensions of our engines have reached a point now where in my opinion the outside motion should replace the link motion.

Chairman:

We have Mr. Curtis with us to-night, and would like to hear from him.

Mr. Theo. H. Curtis:—

Mr. President and gentlemen. I have enjoyed Mr. Williams' paper very much. Having had experience with a good many of the different valve motions I was able to follow Mr. Young's remarks very closely. Looking back over

some years, the first locomotive I ever remember had the Hook motion. I do not know if you know what it is but it had only a cut off at full forward and full back position —you had no intermediate choice whatever. With regard to the link motion; which is said to be a back number, it was a good motion but as the weight of the locomotives increased and also the diameter of the axles, larger eccentrics were necessary until we had a 21″ eccentric with a 63″ driving wheel and when the locomotive was making 60 miles an hour the eccentric was slipping one third or 20 miles per hour in the strap. It was this and the important matter of lubrication that put the link motion out of business. In regard to the Walschaert gear which Mr. Williams mentions as being used in Europe; this gear was used for over forty years on the continent of Europe before it was put on the market in America and I do not know what was the matter with our mechanical engineers that they did not adopt it before.

Coming to matter of valve motion,—the point is to get the steam into the cylinder to accelerate the piston and then get it out when we are through with it and the valve that gives the best opening on the fore part of the stroke of the piston is the one that lets it in the best. Some stationary engines have valves of the Corliss type that shut and open by vacuum means which gives a quick closure after leaving the valve open a long time thus giving a good steam line and a free cut-off and thus permitting of a long expansion, and in expansion there is economy. I am not prepared to speak upon the relative values of the different valve gears.

You have seen diagram (Fig. 1) in this paper of how you can lay off the movement of valves. You can do this in your own roundhouse or shop by getting a board about 36″ long for a locomotive with 30″ stroke. Lay off on this board the steam port of the valve and then lay off each inch of the stroke on the board; then commence with the engine in dead centre and mark on the board the zero point position of the valves; then move the piston one inch and lay off the valve position again, and so on until the 30 inches of stroke have been designated and you have a valve diagram at the roundhouse, made to order. It is not the square sound of the exhaust, but it is the steam that gets into the cylinders that makes the good working engine. With your roundhouse diagram you may then compare one locomotive with another and get a good idea of the relative valve motions of the different locomotives. In service some

engines are good and some are poor, and possibly this valve diagram would tell you why some are poor. Mr. Young spoke about the large opening and high speed of a valve, that gives us plenty of steam and that steam is what makes the engine go.

Mr. F. Williams:—

Mr. Young took me up on my statement that as far as economical steam distribution is concerned valve motion design has to-day reached a point where it cannot be greatly improved upon. I still stand by that statement. If we take a Corliss stationary engine as possessing the nearest approach to a perfect steam distribution, I do not think that a simple engine running non-condensing will do much better than 20 lbs. of superheated steam per H.P. hour and we have been able to get this result on locomotives. Mr. Young also spoke of the size of distribution valves necessary with different diameters of cylinder and based his reasoning on a 12" valve for a 20" cylinder. Is it not just possible that the 12" valve is larger than is absolutely necessary for this size of cylinder? We are getting good results from a 14" valve on a 24" and a 27" cylinder. I think Mr. Comley of the Franklin Railway Supply Company is here, and I believe his company is advocating a smaller valve than we are using, perhaps he can tell us something about it. I think the results obtained in our service by the use of the Walschaert valve gear will compare favorably with other gears. Another point is that when a test is to be made the Walschaert gear is not always given a proper show. If any company has a patent gear to sell and a test is to be made, they send an expert to supervise the application of the gear and see that it is tuned up to the highest point of perfection whereas the Walschaert gear as often as not, only receives the attention of the roundhouse valve setter and, although these men are usually thoroughly competent, the engine is generally turned out without a complete sequence of valve events being takn or recorded, consequently the patent gear, I feel confident that it would hold its own pretty well with any gear tried out against it. Is Mr. Comley here?

Mr. W. T. Comley:—

The arrangement referred to by Mr. Williams is known as the Streamline Cylinder Ports. These ports make application of the well known principles governing the flow of

gases, principles recognized as fundamental in the design of steam turbines. The steam port around the bushing is so arranged that during the admission period, as steam issues from the valve it is divided into a number of streams, depending upon the number of bridges in the bushing. These streams are directed by ribs so that they do not interfere with each other but join into one smoothly flowing whole when the main passage is reached. During the exhaust stroke the steam as it flows from the cylinder to the valve is divided by the ribs into a number of equal streams, one to each port in the bushing. Absence of all quick turns and other baffling obstructions speeds up the flow of steam, and by properly directing the flow of steam to and from the valve every square inch of the bushing port becomes effective. This arrangement permits the use of 8 and 10 inch valves where 14 and 16 inch valves were considered necessary, and at the same time facilitates the flow of steam to and from the cylinder to such an extent that the locomotive is noticeably smarter and faster.

Mr. O. W. Young:—

In answer to Mr. Williams, permit me to say that I merely attempted to point out that in the proportions that are commonly carried between the smaller and larger locomotives we are not keeping consistent in the valve sizes and the width of port openings in proportion to the cylinder volumes that are handled.

I did not come to this meeting to exploit to you gentlement any particular device but am merely attempting to give you something to think about with the object of improving the service in the arrangement of steam distribution.

Mr. C. P. McGinnis:—

I do not know that I ever listened to a paper that stated this subject as clearly as the paper read by Mr. Williams. It has been my fortune—representing a supply concern—to travel a good deal around the country and I am a member of six or seven Railway Clubs, also I was a member of this Club, but believe I have allowed my membership to lapse. I have listened to a good many papers on this subject of valve motion, but they were all more or less ambiguous, and required some explanation. I have read Mr. Williams' paper through four times and do not think there is a single ambiguous statement in it. It is clear and concise and I am sure the Canadian Railway Club are to be congratulated in

having a paper of this kind as part of their minutes. One of our men was overseas and brought back a book published by the Belgian State Railways. It dealt particularly with the works of A. Walschaert, who was at that time 21 years old. At 27 years old he was Engineer of the State Railways, and it was interesting to note that in 1839, after experimenting with the Stephenson link motion they were then using on the engines, which were very small, he found that 2% and almost 3% of the tractive effort of the engine was asorbed in operating four large eccentrics which are fundamentally the Stephenson motion. Larger eccentrics were later on necessary and with the shorter valve travel they could cut down the wearing surfaces. His efforts to produce an improved valve motion were along the line of cutting down friction, although in this country we have come to believe that it came because the engines were getting bigger, and the larger boxes, frame bracing, etc., made it necessary to go to the use of an outside gear. A Walschaert's idea was to reduce friction and do away with the four large eccentrics, and put on an outside gear that would restore the tractive effort to almost 100% of its accredited efficiency. I only mention this to show that it is odd that we did not adopt the outside valve gear before in an effort to get away from the friction. I cannot find any difference in the arrangement or size or designs of 1841 as compared with the locomotive of to-day.

Mr. Williams, in his paper, has outlined some of the fundamental truths of this matter. I remember some time ago in the southwest part of the country listening to a paper on valve motion. It was lengthy and many ways were shown that might have been adopted to get the steam in quickly and emit it quickly again, and how that to-day we do not get a bad starting engine because of the constant lead in full gear; and one of the foremost railroad men got up and said that as they were spending so much time and money to develop valve gears they should try to get away from the constant lead because it made a bad starting engine. I do not think anybody is going to say that about Mr. Williams' paper because in one paragraph he covered that part of the subject.

I have made a few notes and should like to ask Mr. Williams some questions. On page 19, paragraph 7, he says: "Care must be taken that the length of the combination lever adopted will bring the lower end of the lever to the correct level to connect up with the union link, especially if the union link is connected directly to the wrist pin, which

is the practice generally adopted unless the Ripken Kingan main rod arm is used." I should like to ask him if it is not the usual practice in locomotive construction that the union link should be horizontal when the combination link is in vertical position for inside admission valves, and for outside admission valves is it not the practice that the union link should be horizontal at the end of the stroke,—this being necessary to correct inequalities between the front and back ports. I think it was established some years ago that if possible it was good practice to maintain the union link one sixth the length of the main rod, and if that could be done then all errors could be eliminated.

On page 21, paragraph 3, he says: "The advantages of this arrangement are that the wear on the link support bearings is diminished and the link block slip in running position may be kept very small, as the swing link describes an arc which is very similar to the arc struck by a point in the bottom of the link, the concave side of both these arcs being uppermost."

On one road in the New England States I think there are only six engines out of some four or five hundred on which they have not adopted the practice of having the link block at the top of the link in forward gear, and I would like to ask Mr. Williams, if he has not disregarded this practice, if he has not found that he gets better steam distribution by having the link block at the top of the link. A good many roads feel they get better steam distribution, and that one of the best ways to waste coal is to have an unequal steam distribution.

On page 26, paragraph 7, the paper says: "We have already seen that reducing the lead will give us a better cut-off in starting position, and have decided, I think, that this is an advantage when starting the load. Reducing the steam lap has the effect of lessening the period of expansion, but by reducing the exhaust clearance the period of expansion is lengthened and thus the ill effects of cutting down the steam lap is neutralized."

When you reduce the steam lap and the exhaust, do not both of these changes tend to reduce the opening through which the exhaust must pass. There may be advantages but it seems to me you do these things at the expense of the exhaust opening. If a perfect steam distribution gives perfect exhaust why does a perfect sounding exhaust not give perfect steam distribution? If the exhaust is regular and the valve setting is known to be correct does it not indicate

leaking valve or cylinder packing. I would like to ask Mr. Williams about changing the eccentric crank to give an engine a greater maximum cut-off. I had an experience on one of the Western Lines where a number of the passenger engines that took the trains out of St. Paul stalled on a stiff grade, but after they got a crossed lead they made a much better showing in getting over that particular point; they then went a little farther and set a number of the engines in the same way, and it worked alright, but on one occasion an engine handling a freight train pulled into a passing track to allow a passenger train to go by and had to back out but it could not do so,—the result was that they took off all the crossed lead on engines on that road. Later, on one of the Western Roads in Canada eleven engines in passenger service were set with the crossed lead. I think it made them slightly blind in full gear. It worked out very well as long as they did not have to back out of any siding or were run in one direction only.

Mr. F. Williams:—

In reply to Mr. McGinnis' question as to the correct level of the bottom of the combination lever to connect up with the union link: When the union link is connected to the wrist pin we have a very short combination lever and the shorter the lever the greater is the extreme angularity of the union link. On this account we generally find it advisable to have the bottom connection of the combination lever slightly below the centre line of the wrist pin for inside admission valves in order to reduce the extreme angularity of the union link, especialy if the union link itself is short. When we use a crosshead arm we have more latitude with the length of our combination lever as we can increase or decrease the depth of the crosshead arm to obtain just what we want, but when we make the connection directly to the wrist pin we haven't much choice in the matter.

Mr. C. P. McGinnis:—

I take it that you do not have reference to engines that have the combination lever driven from the crosshead pin?

Mr. F. Williams:—

They were new engines.

Mr. C. P. McGinnis:—

They were engines that had crosshead arms below the level of the guides.

Mr. F. Williams:—

If we make the union link level when the combination lever is vertical we get the maximum angularity when the engine is on dead centres and vice-versa, and we have found it advisable to follow the practice I have just outlined in order to reduce the extreme angularity of the union link when using the short combination lever. The rule referred to by Mr. McGinnis was always followed when the long combination lever was in vogue.

Mr. C. P. McGinnis:—

In the later designs has it been possible to so locate the valve stem pin and reduce the bar so as to connect the union link one-sixth the length of the main rod?

Mr. F. Williams:

I have never considered the union link in connection with the main rod and have never heard anyone mention that subject before. With reference to paragraph 7, on page 26, which speaks of reducing the lead; this has reference to freight engines which are generally operated on a long cut-off and at a slower speed and they therefore do not require the same relative exhaust port opening on a 25% cut-off as the passenger engines do. That is why it is possible to cut down the lead and lap and eliminate the exhaust clearance.

Mr. C. P. McGinnis:—

It is seldom used at 25%?

Mr. F. Williams:—

If they are hauling their full tonnage they are loaded too heavily to run on a 25% cut-off. With reference to page 21, paragraph 3: Mr. McGinnis asks if it is not a fact that a better steam distribution can be obtained with the link block in the top of the link. It may be that on certain engines you do get a better steam distribution with the block in the top of the link, but there is no necessity for it. I remember some engines we had built with this indirect motion and they had a good steam distribution; on a subsequent duplicate order we specified direct motion, and if we had simply rearranged the power reverse gear and eccen-

tric crank and left the rest of the motion as it was, the steam distribution would have suffered. It was found desirable to change the location of the reverse shaft slightly in order to eliminate as nearly as possible the link block slip in the new running position and the engines when delivered had as good a steam distribution as the previous order. There is nothing in the idea that a better distribution can be obtained with the link block in the top of the link, but when designing a Walschaert gear special attention should always be given to the running position in fore gear whether this is in the top or the bottom of the link, and it would be very poor policy to indiscriminately change direct motion to indirect or vice-versa without first making sure that the steam distribution in running position would not suffer.

In answer to the question: "If a perfect steam distribution gives a perfect exhaust, why does not a perfect sounding exhaust give a perfect steam distribution?" In the great majority of cases a perfect sounding exhaust does indicate a good steam distribution, but it is not absolutely necessary that it should do so. In my own experience I have had occasion to look into the performance of locomotives which were reported as sounding perfectly square, but on being tried over they were found to be considerably out and yet the combination of valve events gave an even exhaust. Mr. McGinnis' remarks on crossed lead are quite in accordance with my own ideas which were outlined in the paper.

Mr. T. H. Curtis:—

I would like to mention, in connection with valve motion of locomotives, that when the high pressure steam is at the ends of the piston valve which is balanced, there is a valve stem having an area of something like 4 square inches at one end of the valve chamber but not at the other end, thus making a pressure of 800 pounds more on the forward end of the valve than on the rear, for 200 pounds steam pressure; this unequal pressure will slip the valve toward the rear when the inertia of the valve is overcome, thereby causing excessive lead at the front end of the piston stroke which will cause a pound in the driving box, although one may take the valve tram and run over the valves only to find them 'square.' They are square only when the steam pressure is low or off.

Another thing indirectly connected with valve motion; all steam distribution has so-called back pressure, for on

the return stroke we do have "back pressure" and the clearance at the end of the stroke is the only place to put this pressure. if we have too little clearance we have a poorly running locomotive and one that is not economical. I was hoping that Mr. Williams or someone else would touch upon this matter of proper clearance, as it is a very important item.

Secretary :—

I wish here to propose a vote of thanks to Mr. Williams and Mr. Young, for their papers, and to all the other gentlemen who have spoken to-night. I feel deeply gratified at the very fine discussion which has taken place, and think you will all bear me out in saying that we have had a good evening and an excellent discussion.

Mr. Norman Holland :—

I take pleasure in seconding the vote of thanks, and to state that this paper will be just another added to the many excellent papers that have been read before this club in the past.

Chairman :—

It has been moved by our Secretary, seconded by Mr. Holland that a vote of thanks be extended Mr. Williams for his paper. Carried.

Mr. Williams :—

Gentlemen, I wish to thank you for your appreciation of my paper. This is the first time I have had the pleasure of being present at one of your meetings, but I hope it will not be the last.

Chairman :—

The Secretary has provided refreshments and I hope you will remain for a short time and partake of same.

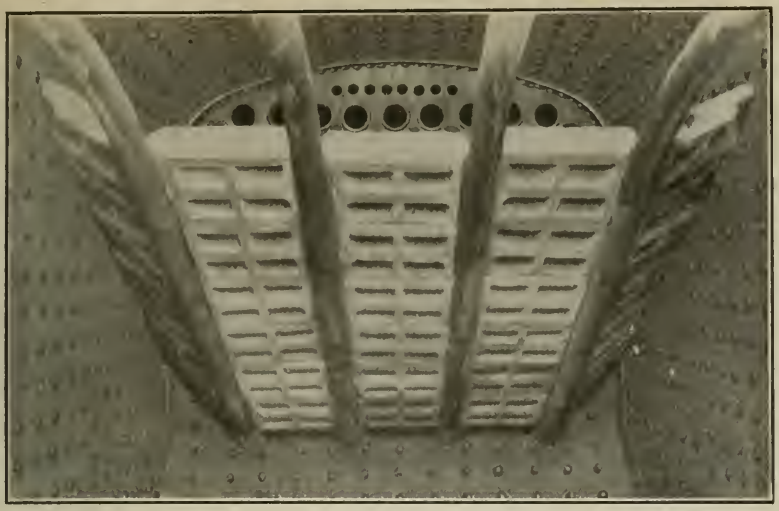
In Memoriam

GEO. DUFF
Died November 19th, 1919

F. D. LYMAN
Died October 2nd, 1919

HARRY OSBORNE
Died March 17th, 1920

M. J. STACK
Died March 1st, 1920



SECURITY SECTIONAL ARCH

"Economy is in itself a source of great revenue."

Coal economy on your Railroads will give the biggest return of any one thing.

Coal economy means not only saving coal but getting all the heat out of all the coal you burn.

Security Sectional Arches baffle and mix the gases with air and get more complete combustion.

Their rough, interfering undersurface stops breaks up, mixes and burns all combustible in the coal.

Real coal economy on locomotives is impossible without Security Sectional Arches.

SECURITY BAFFLING ARCH

AMERICAN ARCH CO.

30 CHURCH STREET - - - NEW YORK

Canada Iron Foundries, Limited

MANUFACTURERS OF

Car Wheels, Cast Iron Water and Gas Pipe,
Flanged Pipe, Specials, Valves,
Hydrants, Etc.

CASTINGS OF ALL KINDS

WORKS AT

Hamilton, Ont. St. Thomas, Ont. Midland, Ont. Fort William, Ont.
Montreal, P.Q. Three Rivers, P.Q. Londonderry, N.S.

Head Office:
MARK FISHER BUILDING
MONTREAL

The Young Locomotive Valve Gear

Assures
LOW MAINTENANCE COST
PERMANENT ADJUSTMENT
Dependable
STARTING AND ACCELLERATING POWER
Maximum
SPEED WITH HEAVIEST TRAINS
Minimum
FUEL AND WATER CONSUMPTION
It Combines
SIMPLICITY and DURABILITY with
EFFICIENCY and ECONOMY

Write for our descriptive booklet

THE PYLE-NATIONAL COMPANY

1334 North Kostner Ave., Chicago, Ill., U.S.A.

"HISCO" PRODUCTS

Include Car Castings and Locomotive Parts of every description

DRIVING WHEELS
ENGINE FRAMES, BUMPERS
CENTRE PLATES, Etc.

THE HOME OF "HISCO" PRODUCTS

The Hull Iron & Steel Foundries
LIMITED

Manufacturers of

CHROME, CHROME NICKEL, MANGANESE
AND MILD STEEL CASTINGS

HULL - - - - CANADA

ACID ELECTRIC
STEEL CASTINGS
Weight up to 15 tons.
RAILROAD CASTINGS A SPECIALTY
PROMPT DELIVERIES PRICES ON APPLICATION
The THOS. DAVIDSON MFG. CO., Limited
Steel Foundry Division, Lachine Canal
Head Office: 187 Delisle St. Phone Victoria 1492. Montreal

S. F. BOWSER COMPANY, Ltd.
Original Patentees and Manufacturers of
SELF MEASURING PUMPS, GASOLINE AND OIL STORAGE TANKS, FILTRATION EQUIPMENT AND AUTOMATIC OIL MEASURES.
PLANT AND OFFICES:
66-68 FRASER AVENUE - TORONTO, CANADA

NOVO SUPERIOR
HIGH SPEED STEEL

J. & C. WARRANTED CAST STEEL TOOL STEEL FOR EVERY PURPOSE

SOLE AGENTS FOR CANADA
Pilot Steel & Tool Co., Limited
332 St. James Street - - Montreal
F. E. REJALL, *Vice-President and Manager.*
Telephone—Main 2354

EQUIPMENT SPECIALTIES LIMITED

10 St. Antoine Street

Phone Main 6697 **MONTREAL** P. O. Box 1722

CANADIAN AGENT

Buffalo Brake Beams

RAILWAY SPECIALTIES MECHANICAL SPECIALTIES

RUBBER AND METAL HOSE HACK SAW BLADES AND MACHINES

J. M. T. Improved

Pressure Regulating Valve

For Steam and Air

Our patented improvement Insures perfect operation. These valves are in service all over Canada, also abroad.

Steam Gauges--Locomotive Injectors--Safety Valves, &c.

THE JAMES MORRISON BRASS MFG. CO. LIMITED - - TORONTO

The Hanlon Locomotive Sander

ALWAYS RELIABLE

INEXPENSIVE TO MAINTAIN

The Hanlon Bulls Eye Water Glass

GUARDS AND SCREENS UNNECESSARY

ABSOLUTELY SAFE, NO DANGER OF ACCIDENTS WITH THIS GLASS

HANLON LOCOMOTIVE SANDER CO. **Winchester, Mass.**

HUNT-SPILLER GUN IRON

FOR

Locomotive Castings

ELIMINATES ENGINE HOUSE REPAIRS

MADE ONLY BY

HUNT-SPILLER MFG. CORPORATION

W. B. LEACH, President and General Manager.

J. G. PLATT, Sales Manager.

OFFICE AND WORKS:
383 Dorchester Avenue,
So. BOSTON, MASS.

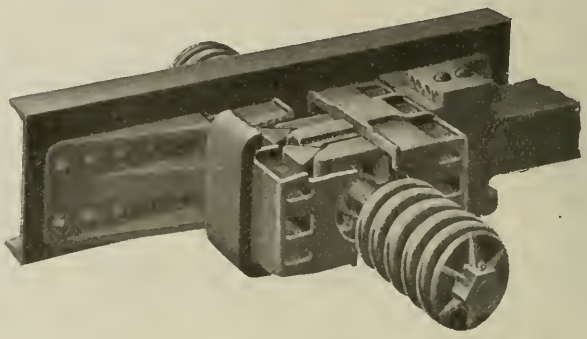
Canadian Representative:
CANUCK SUPPLY COMPANY, LIMITED,
392 St. James St., Montreal P.Q.

WEBB. G. KRAUSER

RAILWAY SUPPLIES

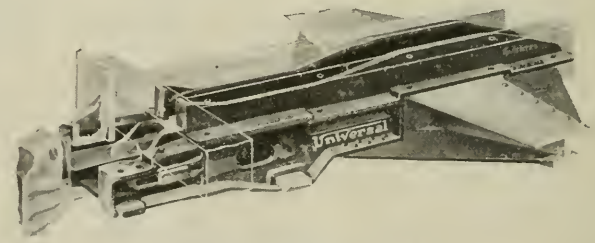
MADE IN CANADA

Cardwell Friction Draft Gear



Universal ATTACHMENTS

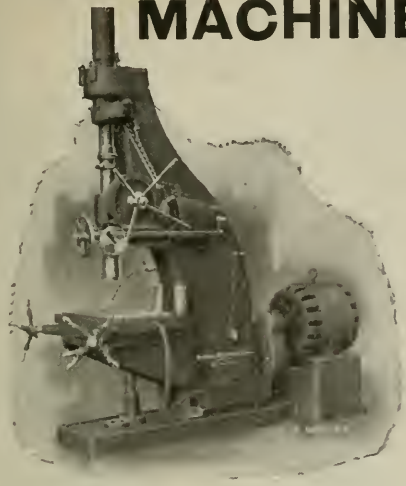
REENFORCING DRAFT ARMS



CAST STEEL YOKES
TANDEM SPRING DRAFT RIGGING
TWIN SPRING DRAFT RIGGING
DRAFT LUGS or PLATES
FRICTIONLESS SIDE BEARINGS.

627 Transportation Building - MONTREAL

BERTRAM
MACHINE TOOLS



Locomotive and Car Shop Machinery

Structural Shop Equipment

General Machine Shop Tools

Modern in Design and built for Heavy Duty.

Photos and Specifications are gladly forwarded on request.

The John Bertram & Sons Co., Ltd.

MONTREAL TORONTO DUNDAS, ONTARIO WINNIPEG VANCOUVER

321 POUNDS OF IRON AND COPPER

has proved sufficient for an economical and reliable car lighting generator when operating with the Stone Franklin Speed Control principle.

Stone Franklin Company

18 East 41st St.
New York

Transportation Bldg.
Montreal

CANADIAN BRONZE, LIMITED

69 DELORIMIER AVENUE

MONTREAL, P.Q.

Journal Bearings for Passenger and Freight Service. Wearing Metal Parts for Locomotives.

Miscellaneous Brass Castings for Cars and Locomotives.

Cold Drawn Seamless Boiler Tubes and Superheater Flues

SPRING STEEL -- P. R. R. ANALYSIS

STAYBOLT IRON — LOWMOOR and NETHERTON

Stocks carried for immediate delivery

DRUMMOND, McCALL & COMPANY, Limited

28 VICTORIA SQUARE, MONTREAL

THERE IS A

JOYCE JACK

FOR EVERY PURPOSE.

We manufacture every kind of jack from a one ton plain lever type to 150 tons hydraulic construction, including self-lowering jacks.

THE JOYCE CRIDLAND CO.

DAYTON, OHIO.

CAR LIGHTING

COMPLETE EQUIPMENT
ELECTRIC OR GAS

GENERATOR, REGULATOR AND FIXTURES

The Safety Car Heating & Lighting Co.

CHICAGO, BOSTON, PHILADELPHIA, ST. LOUIS
MONTREAL, SAN FRANCISCO

2 RECTOR STREET, NEW YORK, N. Y.

SAFETY EFFICIENCY ECONOMY

Reinforced Brake Shoes

DOMINION BRAKE SHOE CO., Limited

THE HOLDEN CO., LIMITED, Agents

350-356 St. James Street - - Montreal. P.Q.

Ludlum Steel Company

MOHAWK EXTRA HIGH SPEED STEEL
SEMINOLE CHISEL STEEL
POMPTON CARBON STEEL

WORKS AT WATERVLIET, N.Y.

Branches at New York, Cambridge, Philadelphia, Detroit, Chicago, Cleveland, Buffalo, Pittsburg.

Canadian Steel-Tire and Wheel Company, Limited

Locomotive and Car Wheel Tires
Steel Tired Wheels of all Kinds

Works: Montreal East

Office: Transportation Bldg., Montreal

TWO PLANTS, CAPACITY 8,000 TONS

Smith's Falls Malleable Castings Company,

Manufacturers of **Limited**

Malleable Iron Castings

Railway Car Castings a Specialty

SMITH'S FALLS, Ontario, Canada

PAINTS FOR FREIGHT CARS

Hard Wearing Service is our First Consideration in the Manufacture of Freight Car Paints

MAPLE LEAF
M L
FINISHES THAT ENDURE
QUALITY
PAINTS & VARNISHES

MADE IN ALL STANDARD SHADES

Let us submit our Samples and Prices
We can meet your Requirements.

MADE IN CANADA BY

THE IMPERIAL VARNISH & COLOR CO. LIMITED
WINNIPEG TORONTO VANCOUVER
CANADA

CAMEL COMPANY

332 So. Michigan Avenue, CHICAGO, ILLINOIS

Camel Freight Car Door Fixtures and Repair Parts
Camel Burglar Proof Freight Car Door Locking Arrangement
Camel Freight Car Door Starting Arrangement

THE HOLDEN COMPANY LIMITED
Canadian Agents:
350 ST. JAMES ST. - - - MONTREAL, QUE. CANADA

Dougall Railway Varnishes

Steel car Liquid Primer and Paste Surfacer (for both wooden and steel cars). We will gladly send you full particulars of the Dougall 15-day Formula, and 7-day Formula (for hurried work).

You should have the details of these systems handy for reference—*write to-day.*

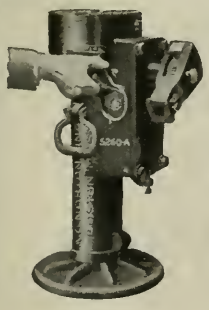
THE DOUGALL VARNISH COMPANY, Limited
MONTREAL.
(ASSOCIATED WITH MURPHY VARNISH CO., U. S. A.)

T. McAVITY & SONS, Ltd.

ST. JOHN, N.B.

Manufacturers of

LOCOMOTIVE BRASSWORK



NORTON Self Lowering Jacks

WILL LIGHTEN YOUR LABOR

They are the Fastest and Easiest working Jacks made

SEND FOR COMPLETE CATALOGUE

Made only by A. O. NORTON, Ltd.
COATICOOK, Prov. Quebec

Stock carried by Canadian Agents:

MUSSENS LIMITED
Montreal, Toronto, Winnipeg, Cobalt, Calgary, Vancouver.

The Best That Can Be Made

GALENA products are generally accepted as the highest grade railway oils possible to manufacture. Their universal reputation is built on a half century's record of exceptional performance on the world's greatest railroads.

GALENA Car, Engine and Coach Oils
GALENA Perfection Valve and Signal Oils
GALENA Railway Safety and Long Time Burner Oils

Are compounded from special stocks by exclusively "*Galena*" processes. They are unequalled for *Quality* and *Uniformity*. The ever-efficient *Galena Service* accompanies them everywhere.

THE GALENA-SIGNAL OIL COMPANY

Works at Toronto. Stocks at Winnipeg, Fort William, Vancouver.
Montreal Office: 603 SHAUGHNESSY BLDG.

HEADLIGHTS—WE MAKE THEM

For OIL, for Pyle ELECTRIC equipment or SPECIAL to Blue Print, and carry a large stock of standard headlight reflectors, burners, burner parts, felt wicks, and chimneys.

The Hiram L. Piper Co., Ltd.
75-81 ST REMI ST., ST. HENRY WARD
MONTREAL

Get our No. 31 Catalogue

ST. THOMAS BRONZE CO. Ltd.

ST. THOMAS, ONT.

BRASS CASTINGS

FOR THE WEARING PARTS OF LOCOMOTIVES

JOURNAL BEARINGS

SAVE COAL by keeping the heating surfaces of your boilers free from scale. One-sixteenth of an inch of scale increases your coal consumption 10.8%.

SAVE WATER AND COAL by reducing the number of times it is necessary to open blow-off cocks to keep the concentration below the foaming point. You are blowing out one pound of coal each second a one and one-half inch blow-off cock is held open.

SAVE BOILER REPAIRS by reducing the amount of work made necessary by leaks caused by scale in your scale-forming water districts, and unnecessary expansion and contraction caused by frequent washing and water changes in your foaming districts.

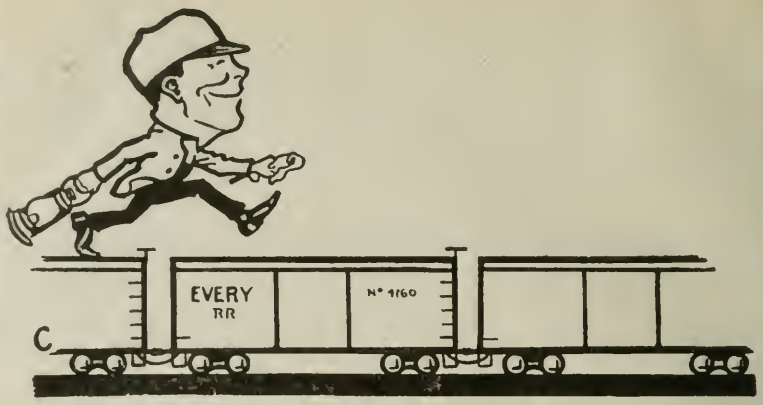
These savings can be effected by adopting the Dearborn System of Water Treatment. The cost is fifty per cent less than any other system now in use.

DEARBORN CHEMICAL COMPANY
OF CANADA, LIMITED

2454-2464 Dundas St. West, TORONTO

413 McIntyre Block WINNIPEG

263 St. James Street MONTREAL



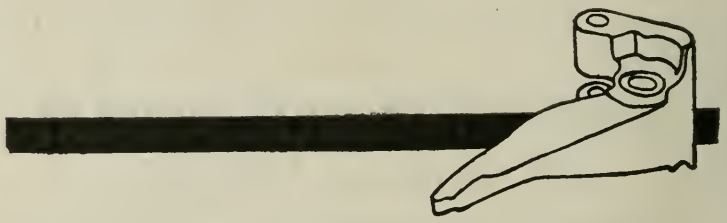
That feeling of Confidence with the

Q AND C

Gilman-Brown Emergency Knuckle

Made in Canada

is what makes them the most popular with trainmen. They slip right into any coupler in general use and maintain the M.C.B. distance between cars. No more chaining up or the delay of turning cars out on sidings



THE GENERAL SUPPLY CO., LTD.

OTTAWA

MONTREAL
TORONTO

WINNIPEG
VANCOUVER

Canadian Car & Foundry Co., Limited
TRANSPORTATION BUILDING, MONTREAL

Passenger and Freight Cars to any Specification

CANADIAN STEEL FOUNDRIES, LIMITED
STEEL CASTINGS
Acid and Basic Open Hearth, Ferro-Alloy
MANGANESE-STEEL TRACKWORK
For Steam and Electric Railways
Transportation Building - Montreal

The Pratt & Letchworth Co., Limited
TRANSPORTATION BUILDING, MONTREAL

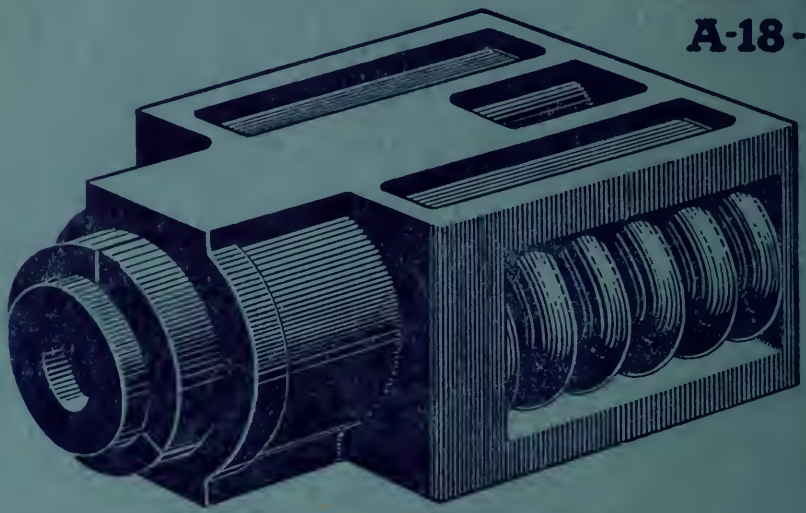
Malleable Castings
For all Purposes
Capacity—2,500 Tons per Month

FOR SALE

MINER

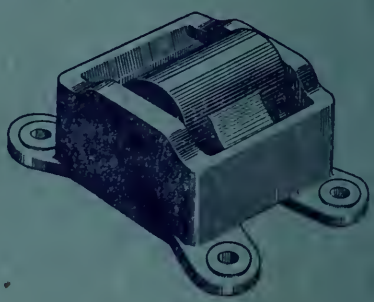
FRICTION DRAFT GEAR

CLASS
A-18-S



THE PERFECT DRAFT GEAR

MINER BALANCED SIDE BEARING



SAVES RAILS, WHEELS AND COAL

CANUCK SUPPLY CO. LIMITED

MONTREAL

W.H.MINER, CHICAGO.